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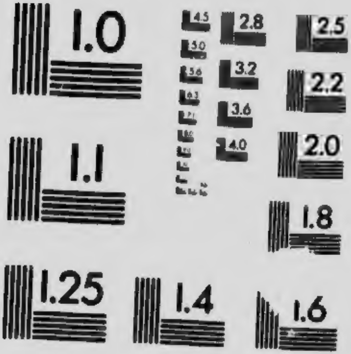

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REPORT TO THE

City of Hamilton

ON QUESTIONS SUBMITTED WITH REFERENCE TO THE CITY WATER-WORKS

AND THE

HYDRO-ELECTRIC DEPARTMENT

Toronto, Ontario, June 25, 1914

REPORT TO THE CITY OF HAMILTON ON QUESTIONS SUBMITTED WITH REFERENCE TO THE CITY WATERWORKS AND THE HYDRO-ELECTRIC DEPARTMENT.

Toronto, Ont., June 23, 1915.

To His Worship the Mayor and Aldermen of the City of Hamilton,

Hamilton, Ontario.

Gentlemen,—

In the annexed report you will find a discussion of two questions, which cover all the matters upon which we were instructed to report.

These questions are as follows:

1. What improvement should be made to the Hamilton Waterworks to bring this system fully up to the standard of modern practice and particularly up to the standards of the Fire Insurance Companies?

2. To what extent can the Waterworks Department and the Hydro-Electric Department be brought into closer co-operation, in order that the expense of carrying on the business of the City as a whole may be reduced to a minimum?

Our conclusions are:

1. We recommend the construction of a new reservoir of ample capacity and at an elevation that will maintain suitable pressures for fire service at the hydrants. There is more than one possible site for such a reservoir and the selection of the final site should be made only after the preparation of closely detailed estimates of construction for the more promising locations.

2. The minimum capacity of the reservoir should be 50,000,000 Imperial gallons, and a site should be selected such that the reservoir may be enlarged from time to time as the City grows. With a reservoir of such capacity, additions to the pumping plant would not be necessary at present.

3. A suitable elevation for the water surface in the reservoir will be at about 275 to 300 ft. above the Bay. With such an elevation the reservoir will furnish satisfactory fire pressures except in parts of the district to the west of James Street and to the south of York Street.

4. As an alternative to the construction of a new reservoir pumping installation might be increased. In this case an emergency supply of power should be arranged for, which will not involve the use of long distance transmission lines. We do not recommend this alternative although it involves considerably less capital cost than will be necessary for the reservoir.

5. The waterworks pumps cannot now be shut down throughout the peak load hours of the Hydro-Electric Department without dangerously reducing the working pressures in the water mains.

6. With the aid of a new reservoir of suitable size, these pumps could be operated entirely off peak and a very considerable saving in the payments by the City to the Hydro-Electric Power Commission for Ontario would result.

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7. The present method of billing the Waterworks Department for electric power furnished to it is equiptable and just as long as the pumps continue to be operated throughout the peak load hours of the Hydro-Electric Department.

8. This method of billing would not be equitable and just if arrangements were made for operating the pumps only during off peak hours. In such event we recommend that the Waterworks Department be billed for the number of k.w. hours of energy actually taken by it and at a rate equal to one-half the cost of such energy as delivered to the City at the Dundurn Street Sub-station plus the cost of transmission from the Sub-station to the Pumping Stations.

9. On the present basis of billing and with the present conditions of demand in each of the Departments, the Waterworks Department can be more economically operated by carrying its peak with steam than with electric power. This condition can be remedied by adding to the reservoir system. To carry the peak with electric power now would only increase the City's power bill from the Province without benefitting either civic department.

10. During the months of small water demand, it would be possible at present to cut off the electric pumps altogether during peak load hours provided that the Osborne-Killey steam pumps were kept in operation, but these steam pumps are not of sufficient capacity to carry the system over the peak load during every month in the year.

11. As a measure of economy, we recommend that the present method of billing consumers for water service be discontinued and replaced by a method in which the bills can be closely adjusted to the cost of the service rendered. The methods of the Hydro-Electric Department might serve as a model for a new system of billing.

12. Extra provision for safety of power service to the Beach Pumping Station should be made by the completion of the construction of duplicate underground circuits from the Dundurn Street Sub-station to the Pumping Station. If overhead circuits are partly used the duplicate lines should be built over different and widely separated routes.

13. A complete and thorough enquiry into the selection of a new reservoir site should be made before further action is taken in connection with this report.

All the technical data upon which this report is based has been most courteously furnished to us by the City Engineer and by the Manager and Chief Engineer of the Hydro-Electric Department. We are greatly indebted to these gentlemen for the assistance they have given us.

Yours respectfully,

KERRY & CHACE, Limited,

Per J. G. G. KERRY, President.

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550 Confederation Life Bldg.,
Toronto, Ont., June 23, 1915.

To His Worship the Mayor and Aldermen of the City of Hamilton,
Hamilton, Ontario.

Gentlemen,—

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In accordance with the instructions given us after our appointment as engineering experts by the Board of Control on December 8, 1914, we have examined the reservoirs and pumping plant of the Hamilton waterworks with the intention especially of determining to what extent the necessary pumping of water supply can be done with off-peak power to be purchased from the Hydro-Electric Department.

We were particularly instructed by a circular letter issued by the City Engineer to inquire into the following points:

Instruction.

1. Method of operating Hydro-Electric and waterworks loads as they now stand or any more economic basis with fair division between these two departments of such saving.

2. Comparison with economic use of existing steam plant for control of peak load with division of cost of operation.

3. Economic advantage of any reservoir either on mountain top or at present level of James Street reservoir, with necessary re-arrangement with suggested division of saving (if any) and operating costs.

4. Economic advantage of taking peak with turbo-generator installed at main waterworks pumping station.

5. Advantages from point of continuity of service of taking power line (and installing necessary plant) from Cataract 66-cycle plant one mile distant with economic advantage (if any) as compared with other reserves mentioned.

6. Comparison of various reserves mentioned, including insurance rates, permanency of water supply in regard to plant, economic operating conditions and possible values to be attached to reservoir for cost purposes.

Briefly these points to be inquired into may be summed up under two headings:

1. What action should be taken to insure the continuous operation of the pumps at the Beach Station under any and all conditions that it is reasonably possible to forsee?

2. How can the pumps at the Beach Station be operated so that the total expense in the purchase of power both by the Waterworks Department and by the Hydro-Electric Department can be reduced to a minimum?

Fire Underwriters' Requirements.

The question of certainty of supply is given particular attention by the Canadian Fire Underwriters' Association, and we are advised that the officers of this Association do not consider that your City is at present as well protected from fire risk as it should be.

The Standard Rules issued by the Association recommend that a city of one hundred thousand people should be provided with an intermediate reservoir having a capacity of 17,500,000 Imperial gallons, that is, provided that the system is primarily a pumping system drawing from a practically inexhaustible supply.

It is also recommended that the system should be capable of carrying the draft of twenty-five standard fire streams for a period of ten hours, this draft amounting to 3,125,000 Imperial gallons in all. Also, that the pumping system both in source of power and in arrangement of pumping units shall be in duplicate to such extent as will ensure that in the event of the failure of any one pump or of anything in connection with the power employed that the immediately available pumping capacity will not be less for a city of the size of Hamilton than 13,125,000 Imperial gallons per twenty-four hours.

It is further recommended that a pressure at the hydrants of not less than eighty pounds per square inch shall be maintained when water is running or if such pressure is not available that the Fire Department shall be equipped with a number of steam fire engines. This number of engines varies with the pressure that is actually obtained under running conditions at the hydrants.

Present Equipment.

The actual equipment which the City possesses for the purpose of meeting these recommendations consists of the main pumping units as in Table "A."

TABLE "A"

Details of Pumps, Hamilton Water Works

Type	Size	Makers	Capacity Imperial Gallons Per 24 Hours	Boiler Pressure Pounds Per Sq. Inch		Date of Installation
Steam Pumps						
2 Vertical Units	Cylinders 20" & 40"	Gartshore	2,500,000	70		1860 altered 1881-2
Tandem Compound	Stroke 8' low press. 6' high "	ditto	2,500,000	70		1860 altered 1881-2
2 Horizontal Units Cross Compound	Cylinders 22" & 44" Stroke 36"	Osborne-Killey ditto	4,250,000 4,250,000	120 120		1887-8 1887-8
Electric Pumps				Head	Speed	Date of Installation
Direct connected motor driven turbine pumps 4 units	16"-2 stage	McDougall-Westinghouse	6,500,000	300	750	1910
	16"-2 stage	ditto	6,500,000	300	750	1910
	16"-2 stage	Mather-Platt	6,500,000	300	750	1914
	16"-2 stage	C.G.E. ditto	6,500,000	300	750	1914

NOTE:—Westinghouse Motor 630 H. P.
C. G. E. Motor 500 K. V. A.

All these units are independent and may, subject to proper power supply, be operated at one and the same time. Such operation, however, would produce pressures in the mains of questionable intensity, the maximum safe discharging capacity of the present system of piping being probably in the neighborhood of 20,000,000 Imperial gallons per day under a maximum pressure of 130 pounds per square inch. This distribution system can readily be enlarged from time to time by a piecemeal process.

The discharge from these pumps is conducted to either one of the two service reservoirs that have been built by the Department, the particulars of which are as follows:

TABLE "B."

Reservoir Details.

RESERVOIR	Surface Area Square Feet.	Elevation of Surface	Depth Feet	Capacity Imperial Gallons
Service Reservoirs:				
Lake Ontario..		245		
Barton Reservoir..	87,500	430	26	10,000,000
James St. Reservoir	32,000	483	6 to 12	1,800,000
Supplementary Reservoirs:				
High Level..	4,800	538	12	285,000
Mountain Tank		740		100,000

Tests made at our request with the James Street Reservoir cut off and with the pumps stopped showed the following pressures to the square inch at hydrants in various portions of the city. (See Table "C").

TABLE "C."

Hydrant Pressures.

Table of pressures when drawing from Barton Reservoir with pumps stopped, April 7, 1915.

Location of Hydrant.	Press. in lbs. per sq. in.	Location of Hydrant.	Press. in lbs. per sq. in.
Kennilworth and Burlington	62	James and Guise............	54
Kennilworth and McAnulty..	52	James and Ferrie..........	42
Kennilworth and Britannia..	50	James and Murray..........	42
Ottawa and Burlington......	63	James and Colbourne......	40
Ottawa and Beach Rd.......	62	James and Vine............	39
Ottawa and Barton..........	52	James and King............	30
Ottawa and Roxborough....	45	James and Jackson.........	28
Ottawa and Main...........	45	James and Young..........	23
Ottawa and King...........	43	Bay and Macaulay..........	45
Ottawa and H.G.&B.Ry.Tr...	30	Bay and Simcoe............	43
Depew and Burlington......	60	Bay and Stuart............	40
Gage and Gertrude..........	60	Bay and York.............	31
Gage and Barton...........	45	Bay and Main..............	24

Gage and King	48	Bay and Bold	14
Gage and Main	45	Bay and Charlton	20
Gage and H.G.&B.Ry.Tr.	30	Queen and Barton	45
Sherman and Burlington	57	Queen and York	28
Sherman and Barton	55	Queen and Market	21
Sherman and Cannon	48	Queen and George	14
Sherman and King	47	Queen and Duke	27
Sherman and Main	45	Queen and Stanley	20
Sherman and T.H.&B.Ry.Tr.	30	Locke and Tecumseh	30
Wentworth at O. Plow Works	55	Locke and York	27
Wentworth and Barton	54	Locke and Florence	22
Wentworth and Cannon	48	Locke and George	19
Wentworth and King	45	Locke and Bold	34
Wentworth and Cumberland	32	Locke and Charlton	26
Wellington and Burlington	62	Dundurn and Jones	18
Wellington and G.T.Ry.Tr.	62	Dundurn and Ardvorlich	30
Wellington and Barton	52	Dundurn and King	35
Wellington and Cannon	48	Dundurn and Melbourne	33
Wellington and King	42	York St. near Desjardin's Canal	18 to 27
Wellington and Charlton	30		

Under these conditions of pressure, and it may be said that such pressures would not be wholly satisfactory for domestic use, the Underwriters' recommendations would call for the purchase and maintenance by the City of approximately ten steam fire engines.

The present steam engine equipment at the Fire Department consists of two steam fire engines of 600 and 800 Imperial gallons per min. capacity, respectively.

With the pumps in operation and pumping directly to the Barton reservoir the following pressures were observed, which may be compared with those given on page No. 8 of this report, and with the Underwriters' requirement of eighty pounds per square inch running pressure. (See Table "D").

TABLE "D."

Hydrant Pressures.

Table of pressures with pumps operating and pumping into Barton reservoir, March 15, 1915.

Location of Hydrant.	Press. in lbs. per sq. in.	Location of Hydrant.	Press. in lbs. per sq. in.
Kenilworth and Burlington	73	James and Murray	65
Kenilworth and McAnulty	62	James and Colbourne	60
Kenilworth and Britannia	60	James and Vine	60
Ottawa and Burlington	72	James at City Hall	40
Ottawa and Beach Rd	72	James and King	51
Ottawa and Barton	62	James and Jackson	45
Ottawa and Roxborough	59	James and Young	40
Ottawa and Main	55	Bay and Macaulay	60
Ottawa and King	47	Bay and Simcoe	43
Ottawa and H.G.&B.Ry.Tr.	30	Bay and Stuart	60
Depew and Burlington	70	Bay and Sheaffe	50
Gage and Gertrude	72	Bay and York	50
Gage and Barton	67	Bay and Main	43
Gage and King	58	Bay and Bold	35

Gage and Main	55	Bay and Charlton	39
Gage and H.G.&B.Ry.Tr.	40	Queen and Barton	64
Sherman and Burlington	71	Queen and York	45
Sherman and Barton	66	Queen and Napier	45
Sherman and Cannon	61	Queen and George	27
Sherman and King	61	Queen and Duke	45
Sherman and Main	55	Queen and Stanley	40
Sherman and T.H&B.Ry.Tr.	40	Locke and Tecumseh	52
Wentworth at O. Plow Works	70	Locke and York	45
Wentworth and Barton	65	Locke and Florence	30
Wentworth and Cannon	62	Locke and George	42
Wentworth and King	57	Locke and Bold	50
Wentworth and Cumberland	40	Locke and Charlton	42
Wellington and Burlington	72	Locke and Homewood	42
Wellington and G.T.Ry.Tr.	70	Dundurn and Jones	30
Wellington and Barton	62	Dundurn and Ardvorlich	37
Wellington and Cannon	60	Dundurn and King	37
Wellington and King	52	Dundurn and Melbourne	45 to 50
Wellington and Charlton	41	Dundurn and Herkimer	47
James and Guise	75	York St. near Desjardin's Canal	35 to 45
James and Ferrie	66		

It will at once be seen that as the James Street reservoir has an ordinary working capacity of only 1,800,000 Imperial gallons that this reservoir would be too nearly exhausted if for any reason the supply from the pumps should happen to be cut off during a single hour of combined heavy service and heavy fire demand. Such combined demand might rise to as high as 1,000,000 Imperial gallons per hour under present conditions. After the end of that hour the city would be practically dependent for fire protection upon the Barton reservoir and the steamers.

It may also be said that while the James Street reservoir is much too small to meet the standard requirements of the Fire Underwriters' Association, the Barton reservoir is not only too small, but that it is at such elevation that satisfactory pressures cannot be maintained throughout the city from this source of supply alone.

The conclusion to be drawn from the foregoing data is that the water system of the city is not of a design that will fully meet the requirements of modern practice in fire protection.

This shortcoming can be remedied either by the construction of a new reservoir of a suitable size and at a suitable elevation or by the enlargement of the Beach Pumping Station. In such an enlargement provision of additional source of power would have to be included, as it would not be satisfactory from the fire protection standpoint to depend upon transmitted power alone.

New Reservoir.

In view of the growth of your city during the last ten years, it would be unwise to make provision for a reservoir that could not be ultimately enlarged to a capacity of fifty million Imperial gallons as a minimum.

The City Engineer is now making inquiries and investigations for the purpose of determining whether a site of suitable capacity and elevation can be obtained for the proposed reservoir. We are of the opinion that no project for the extension or improvement of any of the existing reservoirs should be entertained until these investigations have been completed.

The main points with reference to such a reservoir may be summarized as follows:

1. It should have an immediate capacity of 17,500,000 Imperial gallons in order to meet the requirements of the Fire Underwriters' Association. The site should be chosen so that the reservoir can as occasion demands, be enlarged to a minimum of 50,000,000 Imperial gallons capacity.

2. It would be preferable to construct a reservoir having capacity so much in excess of the Underwriters' requirements that the design of the pumping plant and the source of power need not be considered in connection with fire protection. A reservoir having a capacity of 50,000,000 Imperial gallons would about meet this condition at the present time, and this reservoir should be capable of enlargement to a capacity of 125,000,000 Imperial gallons to provide for the probable needs of a city of 300,000 people.

3. The capacity of the reservoir should be such that the pumps can be completely shut down during the peak load hours of the Hydro-Electric Department. Under present conditions this shut down might last for from four to six hours each day, varying with the season of the year. A reservoir of the capacity called for by the Fire Underwriters' Association would fully meet this condition. This reservoir should be at an elevation of approximately fifty feet above the James Street reservoir. The electric pumps at the Beach Pumping Station will work satisfactorily on delivery of water into a reservoir at this elevation, and the working pressures throughout the distribution system will be much improved.

By cutting off the electric pumps entirely during peak load hours the monthly payment to the Hydro-Electric Power Commission will be reduced and operating expenses may be curtailed by a less frequent use of the steam pumps. The total saving should be roughly sufficient to meet the interest on the cost of a new reservoir and its connections.

So far as capital expenditure is concerned the alternative of improving the pumping system is very much cheaper than the construction of a new reservoir, but the reduction of the annual operating charges should compensate for the additional capital expenditure.

Mountain Reservoir.

A suitable reservoir could be readily constructed on the top of the mountain, but on account of the elevation we do not recommend the selection of this site for consideration until it is certain that no site of more suitable elevation can be secured. Our reasons for this decision are as follows:

1. A materially increased [illegible] of power for pumping becomes necessary.

2. Pressure reducing devices will have to be installed between the reservoir and larger portion of the city. Otherwise a considerable part of the distribution system in the streets would have to be rebuilt to take care of the higher pressure or the waste of water would be considerably increased.

3. Pumping equipment at Beach Station would have to be replaced or water would have to be re-pumped from the Ferguson Avenue Station to the mountain top. This would require considerable changes and additions to the equipment at Ferguson Avenue.

A suggestion has been made that the cost of such additional pumping could be reduced by utilizing any water which might be brought down from a mountain reservoir to develop supplementary power and that this supplementary power could be used at peak load hours to reduce the amount of power which is purchased from the Hydro-Electric Power Commission of Ontario.

This arrangement we do not regard as a desirable one because the efficiency of the double process of pumping and of subsequently developing power would be very low, probably not exceeding thirty-five per cent. The variations of the demand upon the mountain reservoir for water from day to day and from season to season are also likely to be of some magnitude and rarely in step with the needs of the Hydro-Electric Department, so that the manager of that department would have great difficulty in availing himself of the assistance that he could theoretically expect to get from the Waterworks Department.

New Pumping Plant.

It is by no means essential that the Waterworks Department should instal and maintain a large reservoir, as many cities of importance are without such an adjunct to their water supply systems depending as an alternative entirely on pumps. However, as is noted further on in this report, the fluctuations of the demand both for electric current and for water throughout the day and from season to season are very marked and no other method of controlling fluctuations of power demand has yet been suggested, which is quite as simple and satisfactory as a variation of the municipal pumping load to suit the increase and decrease of the local demand for electric current.

If the construction of a new reservoir or the enlargement of the old reservoirs is ultimately found to be impracticable the course that will be left open to the City will be to materially increase the capacity of the pumping equipment at the Beach Pumping Station.

At the present time and assuming the construction of an intermediate storage reservoir of proper capacity, there is an ample equipment at the Beach Pumping Station to meet requirements of the Underwriters. These requirements for a city of 100,000 people are fixed at a duplicate pumping installation of sufficient capacity to deliver 13,125,000 Imperial gallons per day.

Should it not be possible to construct a suitable intermediate reservoir the Fire Underwriters' Standard Rules call for a duplicate pumping plant having a capacity of 17,500,000 Imperial gallons per day, and some addition to the steam equipment at the Beach Pumping Station would be considered immediately necessary.

Steam Equipment.

It should be noted in this connection that the pumping capacity called for by the Fire Underwriters for a system with intermediate reservoir is just about equal to the capacity of the two sets of steam pumps now at the Beach Pumping Station. It follows, therefore, that with the growth of the City the steam equipment at the Beach Pumping Station will very shortly become too small to fully meet the demands of the Underwriters and that some increase of steam installation at that station must be provided for in the relatively near future, unless a service reservoir of large capacity is built.

A second point is that the requirements of the Underwriters are based on the assumed average consumption of one hundred Imperial gallons per capita per day. This amount is very nearly what the average consumption of your City has been during the last five years. Such a consumption of water per capita is larger than the best practice calls for and the installation of additional machinery at the Beach Pumping Station might be deferred by a more direct system of charging for water service from which a saving in consumption of possibly as much as twenty-five gallons per capita per day might result. The possibilities of checking the wasteful use of water are referred to later on in this report.

Electric Equipment.

On the electric side the installation at the Beach Station is ample and is open only to the objection that the operating power is brought from a considerable distance and through a more or less complicated series of switching stations, sub-stations, and transmission lines. The actual record of interruptions of power delivery shows that in operation the effect of such interruptions is not serious and in our opinion the installation may be regarded as thoroughly satisfactory.

In view of the fact that the new pump house at the Beach Pumping Station is designed and built so as to provide for the installation of additional electrical units and that the pumping records of the department and our own estimates of cost show that very material economy can be secured by the use of electric power, it is not in our judgment now wise to consider the installation of any new pumps except of the motor driven, direct connected, centrifugal type. With a large number of units in the pump house there is practically no possibility of a disastrous breakdown among the pumping units themselves, and the capacity of such a plant may be cheaply increased from time to time as the growth of the city continues. It is only necessary to provide protection at all times against a possible breakdown in the supply of electric power.

Breakdown Service.

It would not be satisfactory from the point of view of the Fire Underwriters if the Waterworks Department were to arrange for a breakdown service to be given from the transmission system of the Dominion Power and Transmission Company, because both in ultimate source of power and in route for transmission there is a notable similarity between the systems of the Hydro-Electric Power Commission and of the Dominion Power and Transmission Company. Theoretically, at least, great interruptions in delivery of current over the two systems would be likely to occur simultaneously, if at all.

As the Waterworks Department already has a considerable steam installation at the Beach Pumping Station and as the new steam plant of the Dominion Power & Transmission Company is in the immediate neighborhood of the Beach Pumping Station, no supplementary system for supplying power other than steam need be considered. This conclusion is in agreement with the view of the Fire Underwriters' Association, steam being regarded by that Association as the safest of all systems of power supply.

The problem to be solved in this connection is, therefore, whether it would be more economical to enter into a contract with the Dominion Power and Transmission Company for emergency service to be given from the new steam station of that company or to increase the steam installation of the Department at the Beach Pumping Station.

The choice between these two methods for providing constant power supply may safely be made upon a basis of cost alone, as either source of supply would prove to be perfectly satisfactory.

If a contract at reasonable terms can be obtained for such occasional service from an outside company, we are of the opinion that the interests of the City will be better served by a connection with a large steam station that will be under operation for other purposes, than it will be by the installation and maintenance in a ready-to-serve condition of a reserve steam plant. The cost of such a reserve plant can be readily estimated and this has already been inquired into by the officers of the Waterworks Department and by ourselves.

Clearly if a breakdown service contract can be secured such that the properly computed annual costs of maintaining this service will be less than the costs involved in the maintenance and operation of a reserve steam plant, economical management will call for the closing of such a contract. If on the contrary there is no apparent economy in making such contract, it may be said that there are no engineering reasons why it should be closed without reference to cost.

The publication of any cost figures in this connection at the present time would only tend to prejudice the City's interest in any possible negotiations with the Dominion Power and Transmission Company, and they are, therefore, omitted from this report. Our estimates in this connection are available on request at any time.

To sum up this discussion of the alternative plan of increasing the pumping equipment instead of building a reservoir, it may be said that neither the transforming apparatus nor the set of pumping units at the Beach Station needs to have any addition made to it at present. What in our opinion is required is not additional steam pumps but either the installation of a turbo-generator having a minimum capacity equal to the demand of three of the present pumping units or the making of an arrangement for emergency supply with the Dominion Power and Transmission Company.

We do not recommend either of these courses because there is no provision in either of them, which would enable the City to do its pumping with off-peak power only, and such a provision is necessary if the City's utilities are to be operated at a minimum of expense.

Rates for Power Supplied to Waterworks Department.

The other question to be dealt with is the question of arranging for the co-operation of the Waterworks Department and the Hydro-Electric Department so as to reduce the cost of power to the City as a whole.

The factors that enter into this problem are:

1. The contract between the City and the Hydro-Electric Power Commission of Ontario, which provides that the City shall pay for power on a basis of the highest twenty minute peak in any calendar month at the rate of $15.00 per h.p. year.

2. The load factor of the demand upon the Hydro-Electric Department. The following table shows the results of our investigation of this load factor on the assumption that the waterworks load is not being carried by the Hydro-Electric Department. (See Table "E").

TABLE "E."

Hamilton Hydro-Electric System and Waterworks.

Electrical Records for the Day in each month of 1914 upon which maximum peak load occurred:

	General Light and Power Load on Hamilton Hydro-Electric System, exclusive of Beach Pumping Station						Load from the Beach Pumping Station				Entire System, including the Beach Pumping Station				
MONTH	Max. 20 min peak K.W.	K.W. hours for day	Load factor for day.	Add'l K.W. hrs. to bring load factor to 100 p.c.	Ave. daily K.W. hrs. during month.	Monthly load factor.	Max. 20 min peak K.W.	K.W. hours for day	Ave. daily K.W. hrs. during month	Load factor for day	Max. 20 min peak K.W.	K.W. hours for day	Load factor for day	Ave. daily K.W. hrs. during month.	Monthly load factor.
Jan.	3625	55086	.63	32100			605	12200	13570	.91	4240	68286	67		
Feb.	3655	53628	61	34100			650	14450	11100	.92	4305	68058	.66		
March	3800	49811	.55	41400			[illegible]	14115	13980	.93	4430	63926	60		
April	3900	54152	.58	39300			620	13970	13770	.94	4490	[illegible]	.63		
May	3870	50665	.55	42100			625	13970	13960	93	4475	64635	60		
June	3665	46224	.52	41800			625	14110	14030	94	4263	60334	.59		
July	3220	50513	.65	26700			1200	23525	19620	82	4410	74038	.70		
Aug.	3310	47513	.60	31900			1190	17640	18440	62	4460	65153	61		
Sept.	3755	52400	.58	37700			910	16660		.76	4655	69060	.62		
Oct.	3925	58346	.62	35900			900	16420		.76	4770	74760	.65		
Nov.	3900	61007	.65	32500			870	16100		.77	4740	77107	.68		
Dec.	4080	61380	.63	36600	55927	57	765	14920	15010	.81	4835	76300	.66	70937	.61

Notes on Table "E."

January to June one of the McDougall pumps operated pretty steadily, and the peak which amounted to 14% of total pumpage was carried by steam.

July to December two motor driven pumps were run. They were on frequently during the Hamilton Hydro peak, and only 1.7% of the total pumpage was carried by steam. The effect of this change in method of operation is clearly seen in the load factor columns.

Some of the figures for Beach Pumping Station are missing due to fact that watt-meters were out of service for some months.

1100 K.W. in street lighting load was thrown on July 1st. This load together with corresponding K.W. hour consumption has been added to operating records for the months previous to July in order to approximate present conditions.

The monthly load factors will run a few per cent. lower than the daily load factors for days of maximum peak load in the respective months. It is difficult to obtain the monthly load factors for the general light and power load, and a computation of this load factor has been made for the month of December only.

This indicates that the average monthly load factor for 1914 was a little below 60% or in other words over 40% of the power purchased by the City from the Hydro-Electric Power Commission would be wasted or lost so far as the City is concerned, if there were no waterworks pumping to be provided for.

At the present time the peak of the demand from the customers of the Hydro-Electric Department is found to occur during the evening, starting immediately with the throwing on of the street lighting service and lasting from that time until about 11 p.m. On the face of the figures the wasted or lost power per day may be placed at approximately 36,000 k.w. hours, and the records of the Waterworks Department show that the daily demand of that department for pumping purposes is approximately 15,000 k.w. hours.

It is clear, therefore, that if the waterworks demand could be varied at will to suit the idiosyncrasies of the other customers of the Hydro-Electric Department that the lost power of that department would be ample to take care of any calls from the Waterworks Department.

This conclusion should only be accepted after making two very definite reservations:

1. Any argument with regard to wasted power is necessarily based on the terms of the present contract between the City and the Hydro-Electric Power Commission. These terms might for good reason be varied at any time by agreement between the Hydro-Electric Power Commission and the municipalities which it supplies.

2. The Hydro-Electric Department of the City of Hamilton has not been long in operation and it has entered a field which was fairly well served by a competing organization. The business in this department is not yet nearly developed even if the City were to make no further growth. Taking these facts into consideration, it would be unreasonable to expect that the load factor of the Hydro-Electric Department would remain unaltered over any period of years or that its peak load would necessarily continue to occur at the same hour in the day.

In our judgment the load factor of the Hydro-Electric Department will first of all tend to increase as that department secures a larger proportion of the present commercial business or day load. Later on the load factor may fall considerably below its present figure, the load factor of the department being now notably higher than that of many of the companies operating in greater cities. These observations apply to the Hamilton Hydro-Electric load exclusive of waterworks load.

Our conclusion is that in view of a possible change in the wording of the under-lying power contract and in view of the almost certain changes in the load conditions of the Hydro-Electric Department it would be unwise to make any material capital expenditure that in any way depended solely on conclusions drawn from present conditions, and our recommendation of the construction of a reservoir is not based on economy alone. On the other hand any economy that can be secured by changes in operating methods is most desirable.

The third factor in the question is the variation in the demand from the Waterworks Department and in the foregoing table "E" the load factor of the demand made upon the Hydro-Electric Department by the Waterworks Department at various dates in the year 1914 was given.

In explanation of these figures we may say that during the first six months of the year when this load factor was extremely high only one electric pump was operated in the Beach Pumping Station and this pump was run steadily with as heavy load as it could carry. In the second half of the year two pumps were operated electrically at the Beach Pumping Station. The relation between the capacities of the pumps and the water demand from the City is such that the two pumps were not steadily loaded to anything like full load. This fact resulted in daily shut downs of one pump for considerable periods and a consequent falling off of the load factor.

From a study of the figures given above it will be seen that if the two departments are operated in combination that the general load factor of the Hydro-Electric Department can be improved and its peak load reduced with a consequent reduction in payment to be made to the Hydro-Electric Power Commission of Ontario.

This conclusion is made subject to the ability of the Waterworks Department to maintain supply from time to time when its pumps are shut down for the purpose of improving the load condition of the Hydro-Electric Department. At the present time the Waterworks Department could not maintain supply under these conditions. As already pointed out it is not possible to maintain a satisfactory pressure throughout the City unless the James Street reservoir is in service, and the safe ordinary working capacity of this reservoir may be fixed at about 1,000,000 Imperial gallons. The records of the Waterworks Department show that it has been necessary to pump from time to time as much as 800,000 Imperial gallons per hour to meet the general demand from the City, and if to this figure be added an emergency fire demand of about 300,000 Imperial gallons per hour, it is evident as before mentioned that the water level in the James Street reservoir will be very seriously reduced in about an hour after the pumps were closed down.

Furthermore, at the present time the peak of the Hydro-Electric Department commences at sundown and lasts for from three hours in summer to about six hours in winter, and it is the experience of the Waterworks Department that the James Street reservoir is usually at its daily minimum level when the peak demand of the Hydro-Electric Department commences. Under present conditions, therefore, the James Street reservoir has no surplus water in it during the peak load hours of the Hydro-Electric Department and could not safely be used to make up for any deficiency in the supply from the Pumping Station.

The further conclusion can be drawn that if the pumps at the Beach Station were so operated that the James Street reservoir was full at sundown it would nevertheless be necessary to maintain one pump in operation during the period of peak load of the Hydro-Electric Department.

Therefore, until after the construction of an intermediate reservoir of more ample capacity the possibility of securing economy by the cooperation of the two civic utilities is limited to determining whether the extra pumping required over and above delivery of one electric pump shall be done by electric power or by steam.

As proper economy in the use of power requires that centrifugal pumps shall be run at or near full load whenever they are under operation, the pumping units cannot be economically operated by simply using at all times throughout the day just whatever waste power the Hydro-Electric Department has available. Within the limits set by the mechanical characteristics of the pump, this policy of operation should be followed as closely as possible.

The choice between the use of steam and electric power for what may be termed surplus pumping is determined at present by the system of charging followed by the Hydro-Electric Department in rendering account to the Waterworks Department. The present contract between the two departments is similar to that between the City and the Hydro-Electric Power Commission of Ontario in that it requires payment on the basis of the maximum monthly peak, duration of which monthly peak is fixed at twenty minutes. The price is fixed at $16.50 per horsepower year and this figure, we understand, is determined by the general Hydro-Electric principle of power at cost.

In view of the underlying contract with the Hydro-Electric Power Commission of Ontario, it is evident th[illegible] the Hydro-Electric Department cannot afford to alter its method [illegible]ng the Waterworks Department for any power taken by pumping [illegible] which are operated so as to increase the general peak load. We [illegible]o reason, however, why a special rate per kilowatt hour of consumption [illegible]ould not be made to the Waterworks Department for power, which is [illegible]nsumed by pumps that are not operated in any one month during peak [illegible]ad hours.

Such special rate should not be fixed with the sole idea of reducing the cost of pumping to the Waterworks Department. It might happen that a rate, which would not always be advantageous to the Waterworks Department owing to the fluctuations of its load would nevertheless be economical and advantageous to the City as a whole.

Independent of any engineering estimates the records of the Waterworks Department show very clearly the economy that can be obtained by the use of electric power. The following table gives the power cost for pumping one million gallons under various conditions of operation as recorded in the books of the Waterworks Department. (See Table "F").

TABLE "F." (Sheet 1.)

HAMILTON WATERWORKS.

Comparison of costs of pumping by different methods at Beach Pumping Station.

Electric Costs, 1914, for steady pumping:

Month	Cost Power	Gallons Pumped Electrically	Cost Per Million Gals.
January	$1135.60	255,745,000	$4.45
February	1165.31	247,410,000	4.72
March	1126.86	267,302,000	4.22
April	1114.61	252,162,000	4.43
May	1100.67	260,890,000	4.22
June	1109.14	260,533,000	4.26
Total six months	$6752.19	1,544,032,000	
Monthly average	$1125.36	257,339,000	$4.38

TABLE "F." (Sheet 2)

Steam costs, 1914, for carrying peak:

Month	Cost of Coal	Gallons Pumped by Steam	Cost Per Million Gals.
January	$327.40	43,261,000	$7.56
February	278.80	41,965,000	6.65
March	209.60	29,902,000	7.02
April	206.30	28,489,000	7.25
May	302.36	40,226,000	7.53
June	481.87	68,073,000	7.07
Total six months	$1806.33	251,916,000	
Monthly average	$ 301.05	41,986,000	$7.17

TABLE "F." (Sheet 3.)

HAMILTON WATERWORKS.

Month.	Total Electric Pumpage.	Total Cost Power.	Peak Electric Pumpage.*	Cost Peak Power.†	Cost Per Million Gals. Peak Power.
September	301,130,000	$1624.74	43,791,000	$499.38	$11.40
October	282,900,000	1598.54	25,561,000	473.18	18.50
November	274,580,000	1658.80	17,241,000	533.44	31.00
December	282,900,000	1492.98	25,561,000	367.62	14.30
T'l 4 mons.	1,141,510,000	$6375.06	112,154,000	$1873.62	
Monthly Ave.			28,038,500	$ 468.40	$16.70

*Peak electric pumpage obtained by deducting average monthly steady electric pumpage for Jan.-June, 1914, viz. 257,339,000 gallons, from total electric pumpage for month.

†Cost of peak power obtained by deducting average monthly cost steady electric pumpage for Jan.-June, 1914, viz. $1125.36 from total cost electric pumpage for month.

TABLE "F." (Sheet 4.)

SUMMARY.

Period.	Method of Pumping.	Cost Per Million Gallons.
1909	Steam Entirely	$6.42
1910	Steam Entirely	6.34
Average of 2 years	Steam Entirely	6.38
Jan.-June, 1914	Electrical for steady part of load	4.38
Jan.-June, 1914	Steam for Peak Load	7.17
Sept.-Dec., 1914	Electrical for Peak Load	16.70

From these figures it is clear that if power can be purchased by the Waterworks Department on some basis which does not involve any payment for power when the pumps are not in operation that a maximum economy will be obtained by the use of electric power for both peak and off-peak pumping.

Under the present system of billing the Waterworks Department for the power used by it, the books of this Department show, as indicated in the foregoing table, that it is cheaper to carry the peak of the water demand with the steam pumps rather than with the electric pumps.

Such a conclusion is more or less of a fallacy, present costs being determined entirely by the method adopted for billing the Waterworks Department and not by the value of the power actually consumed.

We are of the opinion that the present method of billing the Waterworks Department should be continued so far as those pumps are concerned, which are kept in operation during the peak load hours of the Hydro-Electric Department, but that a rate per kilowatt hour of consumption based on the average cost of the power delivered each month at the Dundurn Street Sub-station might properly be made for all power used by any pump that is not operated in the month during peak load hours. Just what the charge per kilowatt hour should be for such power is a matter that must be settled more or less arbitrarily by the City Council, as the question is one mainly of fairness to the officers managing the two different departments of the City's activities. Our own recommendations will be found further on in this report.

As a matter of technical argument it may be pointed out that the peak load of the Hydro-Electric Department arises at the present time from the demand for current for street lighting, this particular service being under the control of the Hydro-Electric Department. Without this peak load there would be little waste or lost power for the City to take advantage of during the other hours of the day, and the Hydro-Electric Department is, therefore, as a matter of equity entitled to share largely in any economies which result to the City from the use of off-peak power.

On the other hand without the assistance of the reservoirs, which are under the control of the Waterworks Department and represent a considerable proportion of its expenditure it would not be possible to utilize this off-peak power advantageously.

As both the departments, therefore, will contribute to the securing and utilization of this off-peak power we believe that a fair rate of charge to the Waterworks Department per kilowatt hour in each month would be one-half the average cost per kilowatt hour of the power received at the Dundurn Street Sub-station, plus a proper allowance for the cost of transmission from the Sub-station to the Beach Pumping Station. This allowance can be more accurately determined by the officers of the departments than by ourselves.

If the new reservoir were in operation the practical result of this change of the method of operating and of billing would be as follows:

1. The peak load of the Hydro-Electric Department would be reduced by approximately 850 h.p. resulting in a saving in the payments to the Hydro-Electric Power Commission for Ontario at the contract rate of $15.00 per h.p. per annum amounting to $12,750.

2. The present revenue of the Hydro-Electric Department would be decreased by approximately 850 h.p. at $16.50 per h.p. or a total of $14,025, which loss would be largely offset by the revenue to be obtained under the proposed rates for billing.

3. The cost of power to the Waterworks Department under the new arrangement on an assumed delivery of 3,600,000,000 Imperial gallons per annum would be about $10,800.00, which would be paid to the Hydro-Electric Department and would partially offset the loss shown in paragraph two.

In calculating these figures we have assumed an expenditure of 1800 k. w. hours of energy per 1,000,000 Imperial gallons pumped and a total cost price at the Beach Pumping Station of 0.33 of a cent per k. w. hour, one-half of this unit cost being made the basis for the charge to the Waterworks Department.

4. The ultimate gain to the Hydro-Electric Department can be determined by combining the foregoing figures and would amount to above $9,500.00.

5. The Waterworks Department while materially improving its service pressures would spend for power alone about $10,800, as against an estimated expenditure for power and coal under present conditions of $16,000 per annum. There would also be economies in the other items of cost of operating the pumping plants.

6. The total saving to the City would be in the neighborhood of $15,000 per annum against which would have to be placed a considerable portion of the fixed charges for the construction and maintenance of the new reservoir and its connecting lines.

The foregoing figures are necessarily approximate as our instructions from the City do not provide for a close detail investigation of the cost of construction of the proposed works. Such an investigation should certainly be made before any reservoir site is selected. We are satisfied to a preparatory degree that a suitable site can be secured, having been furnished by the City Engineer with much information bearing on this subject.

As a further illustration it may be pointed out that under the proposed rates for off-peak power, there would be some economy to the City in cutting off the electric pumps during peak load hours without waiting for the construction of the new reservoir. This would only be possible during certain months of the year, as the water demand would have to be carried mainly by the Osborne-Killey steam pumps throughout the shutdown. These pumps could not safely carry the water demand during the summer months or during any extremely cold spell in the winter and the possible saving is therefore slightly speculative.

On the assumption that a water supply of 10,000,000 Imperial gallons per day was being maintained and that of this 8,000,000 gals. was being pumped by off-peak electric power and 2,000,000 gals. by steam during peak load hours the cost would work out as follows on the assumption already given.

1. Saving in payment to the Hydro-Electric Power Commission for Ontario—say 850 h.p. at $1.25 per month—$1,062.50.

2. Loss from peak load sales by Hydro-Electric Department—say 850 h.p. at $1.37½ per month—$1,168.75.

3. Gain from off-peak sales by Hydro-Electric Department—say 8,000,000 Imperial gals. pumped per day and 1,800 k. w. hrs. per million gallons and a rate of 0.33/2 cts. per k. w. hr.—$23.76 per day or $722.20 per month.

4. Net saving to Hydro-Electric Department—$616.45 per month.

5. Cost of steam pumping (coal only) say 2,000,000 Imperial gals. pumped per day at $7.00 per 1,000,000 gals.—$14.00 per day of $425.83 per month.

6. Net saving to Waterworks Department—$20.22.
7. Total net saving to City would amount to $616.45 plus $20.09—$636.54 per month.

To carry out this system of charging, it will be necessary to provide facilities at the Beach Pumping Station for the separate metering of the power consumed by each of the electric pumps.

Alternative use of the Barton Reservoir and Re Pumping.

In reaching our conclusion to recommend the construction of a reservoir or reservoirs of large capacity we have not overlooked the fact that a supply of water at proper pressure might with some apparent economy be obtained by arranging to pump every day during peak load hours from the Barton reservoir to the James Street reservoir instead of from the Beach to the James Street reservoir.

If a new pumping station were placed somewhere near the corner of Ottawa Street and Main Street the working pressure at the new station would be approximately seventy feet as against a present pressure at the Beach Pumping Station of approximately two hundred and fifty-five feet, or in other words the amount of power consumption for pumping during peak load hours with such an arrangement would only be approximately thirty per cent. of the amount of power now used.

This reduction, if present methods of operation are followed, would reduce the load taken by the Waterworks Department when running only one electric pumping unit during peak hours from approximately 650 kilowatts to approximately 200 kilowatts, and as all this is peak load power there will be a saving in the power bills of approximately $1.37 per horse-power per month or about $822.00 in all. As against this saving must be charged the expense of constructing, equipping, and maintaining the new station and the expense of operating it.

The books of the Waterworks Department show that the Ferguson Avenue Station, which is of somewhat equal size to the new station that would be required can be operated exclusive of power purchased at a cost of $425.00 per month, and the interest and fixed charges on a new station may be placed at $250.00 per month approximately. From these figures it is evident that the economy to be obtained by the construction of this new station is so small that the erection of such a station is not to be recommended.

This conclusion is made rather more definite by the fact that the main plant of the Hamilton Waterworks has grown without the abandonment of any material construction for nearly sixty years and the deficiencies of the original plant have been largely met by providing small additional facilities such as the James Street reservoir and Ferguson Avenue Pumping Station. We think it is desirable at the present time that the City should make provision for a very considerable enlargement of its waterworks plant along permanent lines, and that no plan for temporary relief such as by pumping from one reservoir to another should be taken under consideration by a City that can look forward confidently to so brilliant a future.

In closing this report we desire to point out that the total power consumed in pumping is not a great proportion of the total amount of power purchased by the Hydro-Electric Department, the usual daily peak demand of the Hydro-Electric Department exclusive of power used at Beach Pumping Station being about 4000 kilowatts and the demand for electric power from the Beach Pumping Station rarely rising as high as 1,000 kilowatts under any conditions of pumping. It may be anticipated that the demand for electric light and power will grow much more rapidly than will the demand for water as the latter should not increase even proportionately to the increase of population, whilst the use of electric power is in process of rapid development.

The question of co-operation between the departments will, therefore, become of relatively less importance from year to year.

Water Consumption.

The following figures compiled by the Waterworks Department give the average consumption per capita during the last ten years. (See Table "G").

TABLE "G."

Year.	Population.	Imperial Gals. of Water Pumped During Year.	Gals. Pumped Per Capita Per Day. Average for Year.
1905	59,547	2,107,111,110	97.0
1906	61,443	2,259,657,670	100.8
1907	64,067	2,515,191,600	107.6
1908	70,000	2,462,644,050	96.5
1909	70,303	2,493,604,000	97.0
1910	73,538	2,686,214,140	100.0
1911	82,095	2,930,477,595	97.8
1912	88,922	3,340,738,879	103.0
1913	100,808	3,661,893,333	99.5
1914	101,344	3,641,916,440	98.5

From this table it will be noted that the increase in the demand for water has been in practically exact proportion to the increase of population during these ten years.

The following figures show the rate of pumping for each hour from 7 a.m., July 31st, to 7 a.m. July 22nd, which was the day of maximum use of water during the year 1914. (See Table "H").

TABLE "H."

Day of Maximum Pumpage During 1914.

	Time.		Hourly Pumpage Imperial Gals.	Rate per 24 hours Imperial Gals.
July 21—	7 to 8		690,000	16,560,000
	8 to 9		600,000	14,400,000
	9 to 10		620,000	14,880,000
	10 to 11		620,000	14,880,000
	11 to 12	noon	605,000	14,520,000
	12 to 1		595,000	14,280,000
	1 to 2		600,000	14,400,000
	2 to 3		580,000	13,920,000
	3 to 4		585,000	14,040,000
	4 to 5		680,000	16,320,000
	5 to 6		470,000	11,280,000
	6 to 7		575,000	13,800,000
	7 to 8		693,000	16,632,000
	8 to 9		810,000	19,440,000
	9 to 10		567,000	13,608,000
	10 to 11		670,000	16,080,000
	11 to 12	midnight	630,000	15,120,000
July 22—	12 to 1		610,000	14,640,000
	1 to 2		500,000	12,000,000
	2 to 3		330,000	7,920,000
	3 to 4		405,000	9,720,000
	4 to 5		275,000	6,600,000
	5 to 6		352,000	8,448,000
	6 to 7		483,000	11,592,000
		Total	13,545,000	

	Gallons.
Maximum rate in any one hour....	19,440,000
Maximum rate per capita per 24 hrs. for any one hour......	192
Average rate per capita per 24 hrs. during entire 24 hrs....	134
Average rate per capita per 24 hrs. for the year 1914....	98.5

As already stated the present consumption of water per capita in the City of Hamilton is a fairly liberal consumption, and could no doubt be materially reduced, if the details concerning the use of water were given the same careful study that is now given to the use of electric current by the Hydro-Electric Commission.

The old-fashioned method of billing the consumer for the use of water on some more or less arbitrary scale based on the assessment of the property, which he happens to occupy, is certainly not a scientific method of charging for the cost of furnishing water to the community. Under this system no real effort is made to ascertain either the amount of water taken by any consumer or the cost of delivering that water to him, and in this respect the methods followed by the Hydro-Electric Department are worthy of adoption.

It is noteworthy that whereas consumption in the City of Hamilton is in the neighborhood of one hundred gallons per capita per day, consumption per capita in the City of Victoria, B.C., is approximately seventy Imperial gallons per capita, rising at midsummer. to approximately ninety Imperial gallons per capita. Victoria is a city which may be fairly compared to Hamilton from a waterworks standpoint, the total population within the waterworks district being said to be well over 60,000 and the weather being exceptionally dry during the summer months. The proportion of detached houses standing in grounds of their own of various areas is larger in Victoria than in Hamilton, and the summer demand is consequently very heavy.

The only reason that can be readily advanced for the more economical use of water in Victoria is that all services in Victoria are metered and the consumer pays for what he uses.

We believe that if the City of Hamilton made arrangement to determine the amount of water used by each consumer and instituted a schedule of rates, which should be proportioned as closely as possible to true cost that there would be a material shrinkage in the consumption per capita and a consequent reduction in the amount of power used for pumping purposes. Probably, also, it would be found that there were leaks of considerable magnitude at various points along the pipe lines, which leaks it is now most difficult to detect because there is no record of the amount of water taken from the pipe lines by individual consumers.

We have the honor to remain,

Yours very truly,

KERRY & CHACE, LIMITED,

Per J. G. G. KERRY, President.